Characterization of Thermal & Mechanical Impact on Aluminum Honeycomb Structures

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Overview

1. About Me
2. Purpose
3. Destructive Analysis
4. NDE Methods
5. Future Work

About Me

Image courtesy of www.nationsonline.org

About Me

- Midwest → "Deep" south. SCIENCE!

Image courtesy of worldtouristmap.info

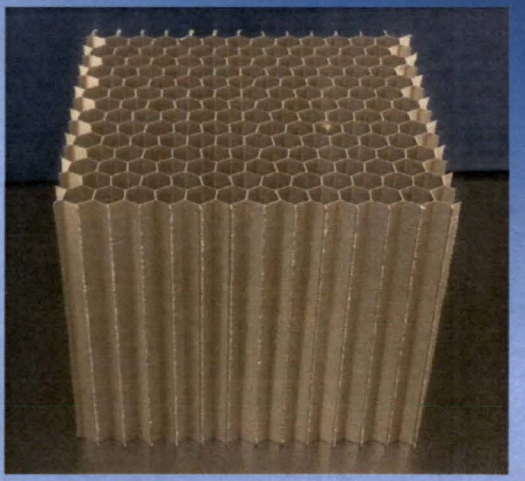
About Me

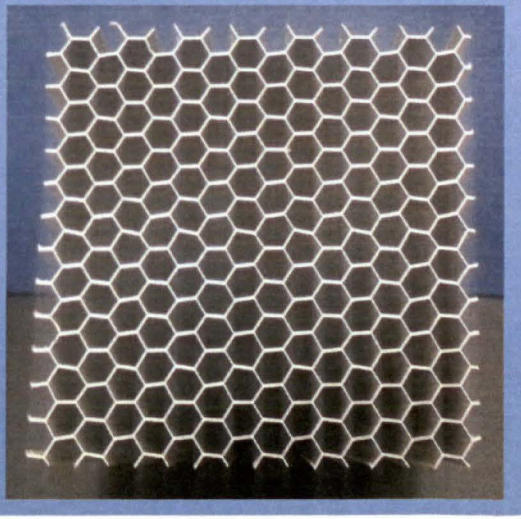
Image courtesy of www.jsums.edu

Image courtesy of www.studioroyale.net

What is the Purpose of This Research?

- Quantitative and qualitative data on Aluminum constructs
  - Energy absorption + Impact
  - Thermal performance
- NDE method development
  - Quality





Goals

1. Effectively measure damage point (volume/area)
2. Image internal compression damage non-destructively
3. Determine impact effects on cellular structure/strength
4. Compare thermal behavior of impacted vs. non-impacted specimens

Why so?

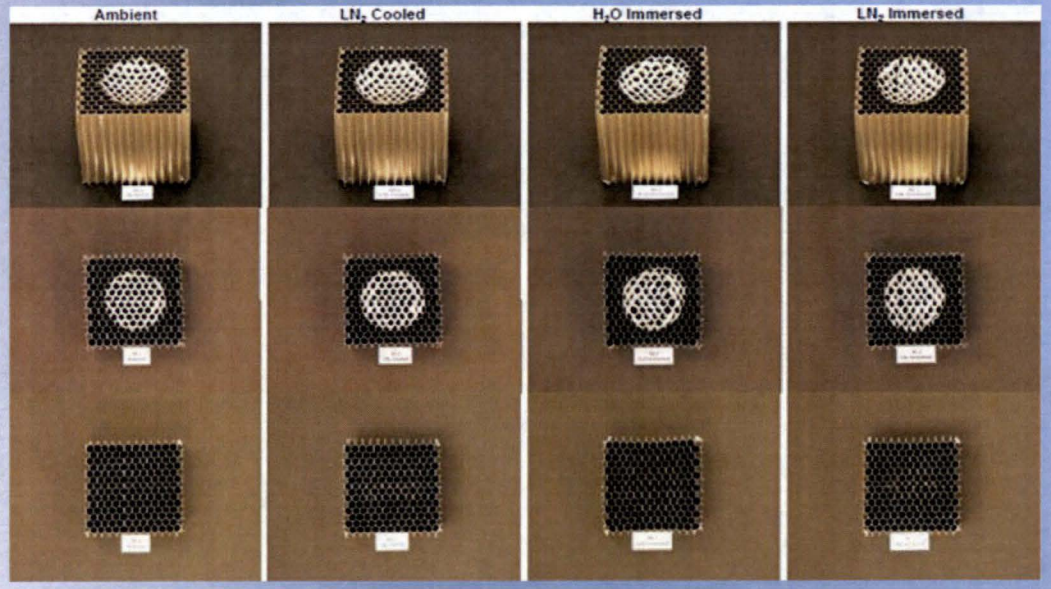
- Space = extreme ΔT environment (high temp down to cryogenic)
  - Habitation, etc.
- Mechanical and thermally Efficient
  - Honeycomb
    - 120° orientation = Surface area reduction
- High cost of fuel to travel in space
    - Aluminum → Durable, lightweight, affordable, tunable material
    - HIGH strength, LOW weight

Honeycomb Structure

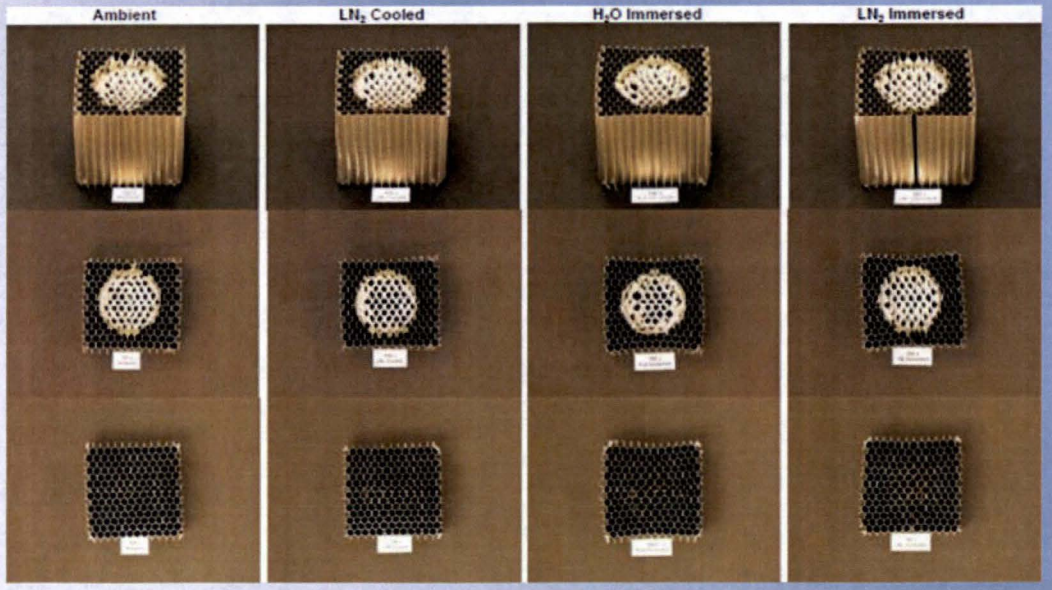
Image courtesy of
http://http://phandroid.s3.amazonaws.com

Image courtesy of http://www.americansweets.co.uk

Honeycomb Structure



50 J Impacted Samples



100 J Impacted Samples

Test Methods

Destructive

- Impact Test
- Compression Test

NDE: Mechanical/Thermal Testing

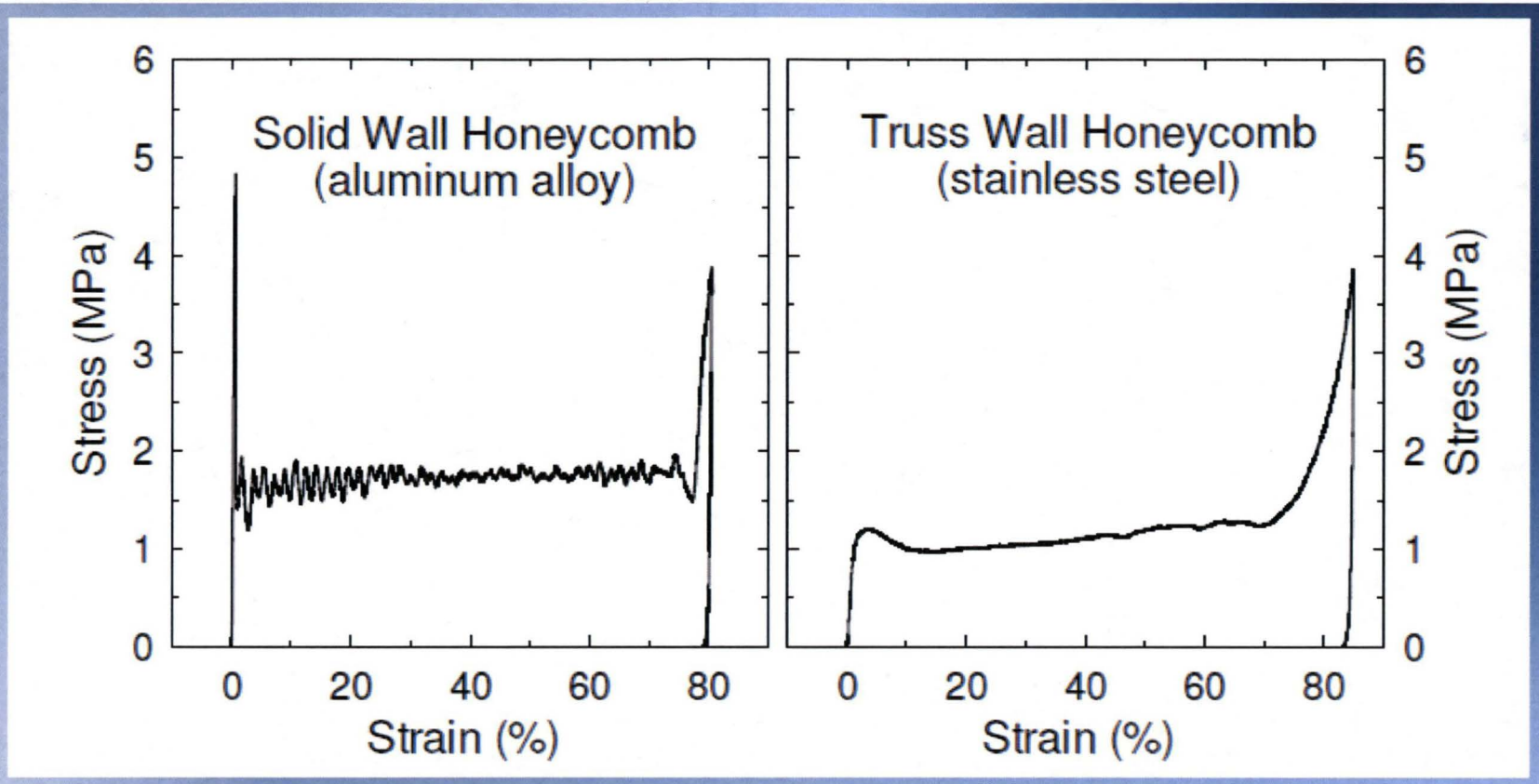
- Cryogenic Thermocouple (Heat flow)
- X-ray
  - CT Scanner
- CMM

Destructive Evaluation

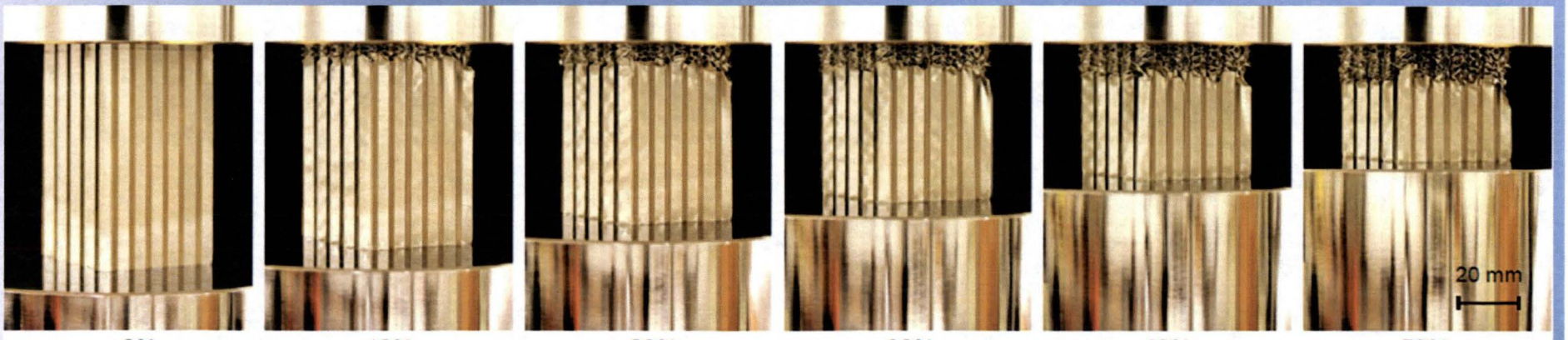
Compression and Impact Testing at Embry-Riddle Aeronautical University

- 30,000 lbs compression
- Stress-Strain behavior

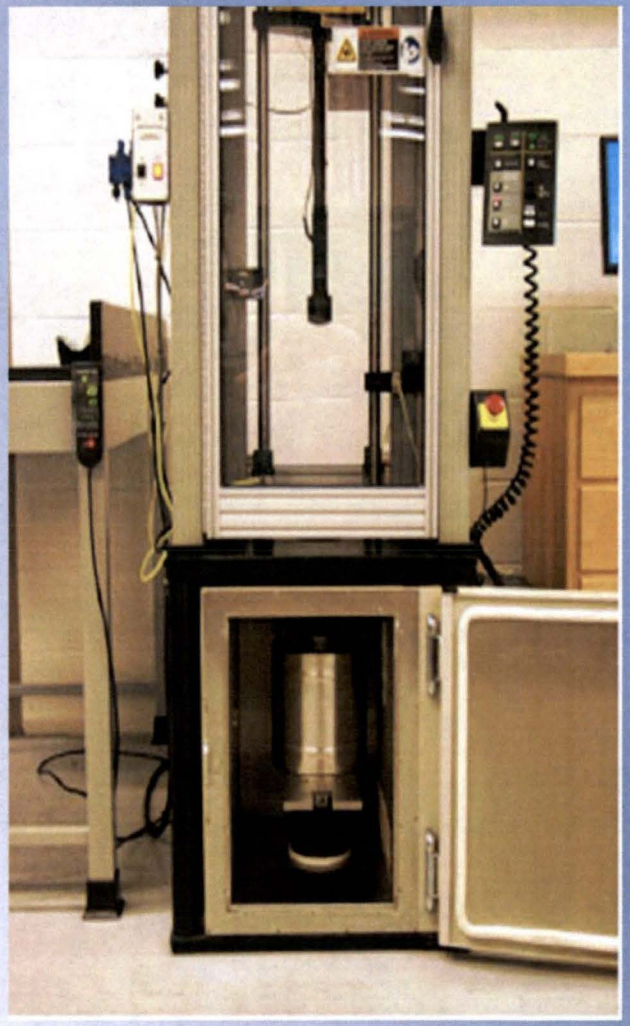
- 50 J Impact
- 100 J Impact
- 200 J + 300 J Impact



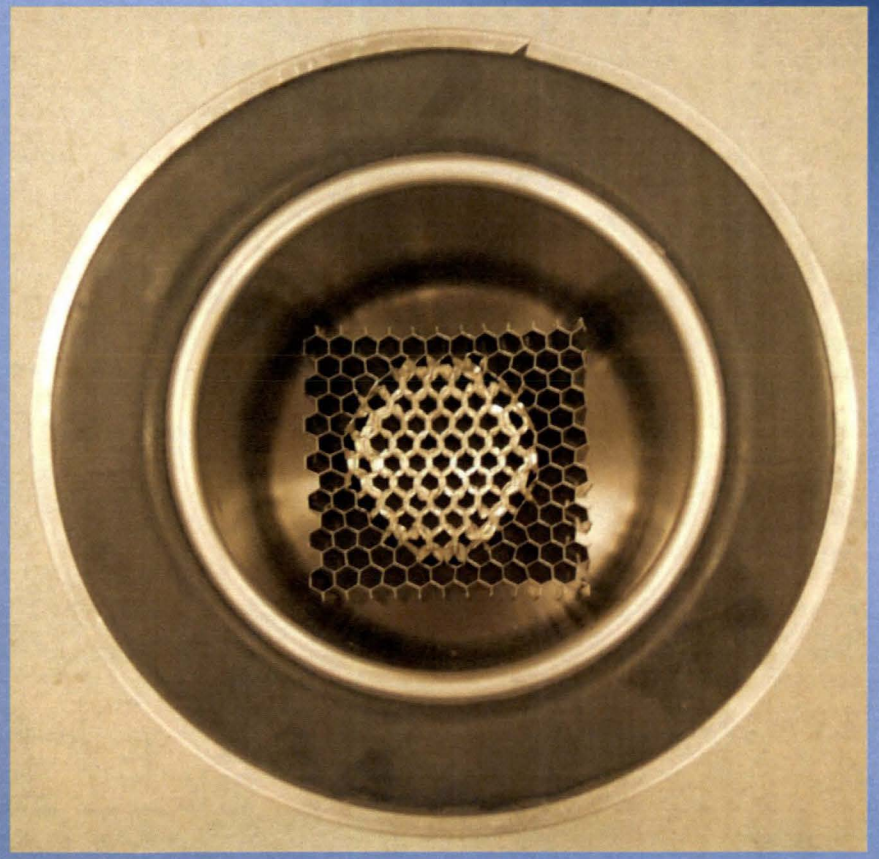
Stress-strain behavior for crushed solid wall (left) and truss wall (right) honeycombs



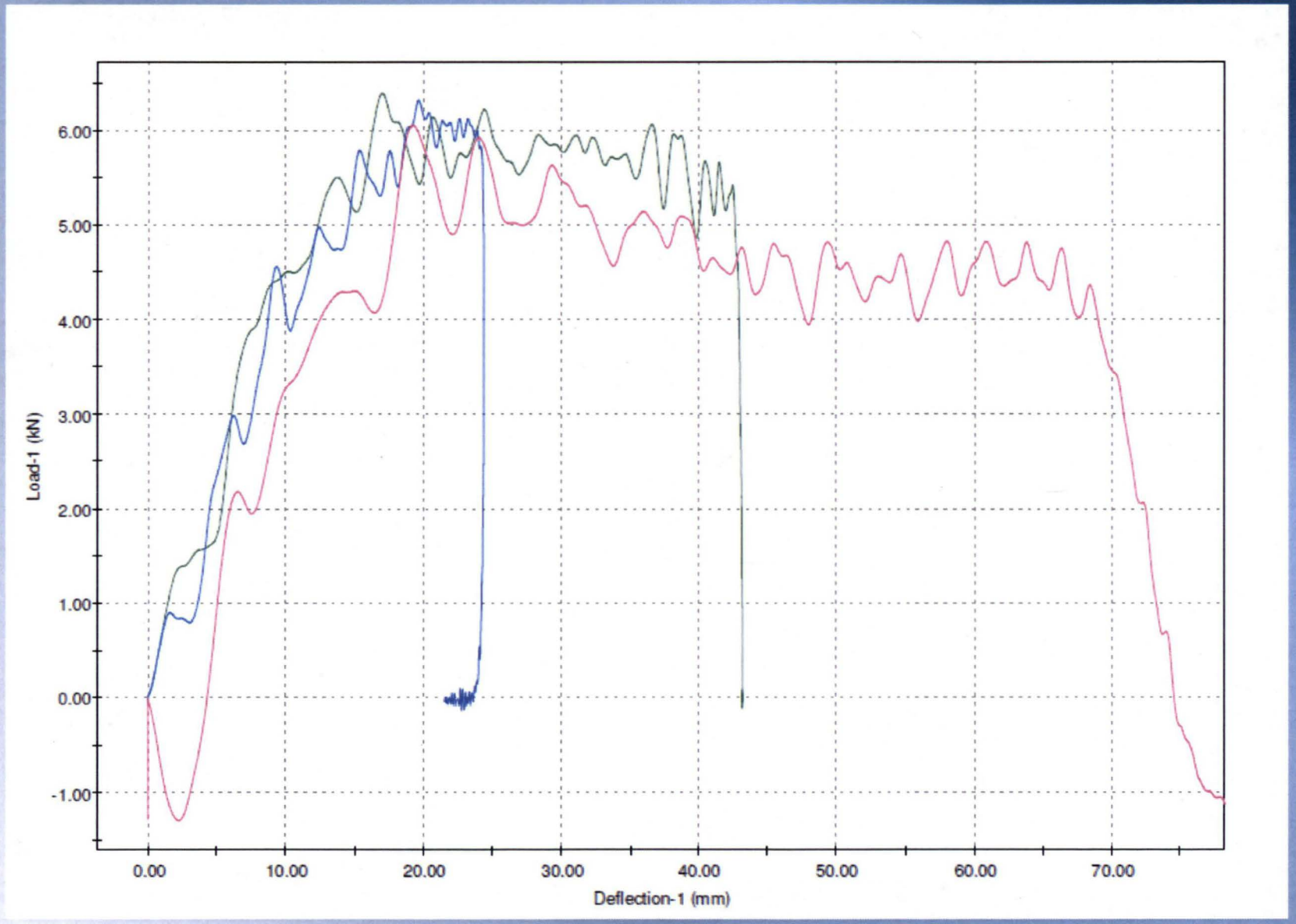
Impact Equipment



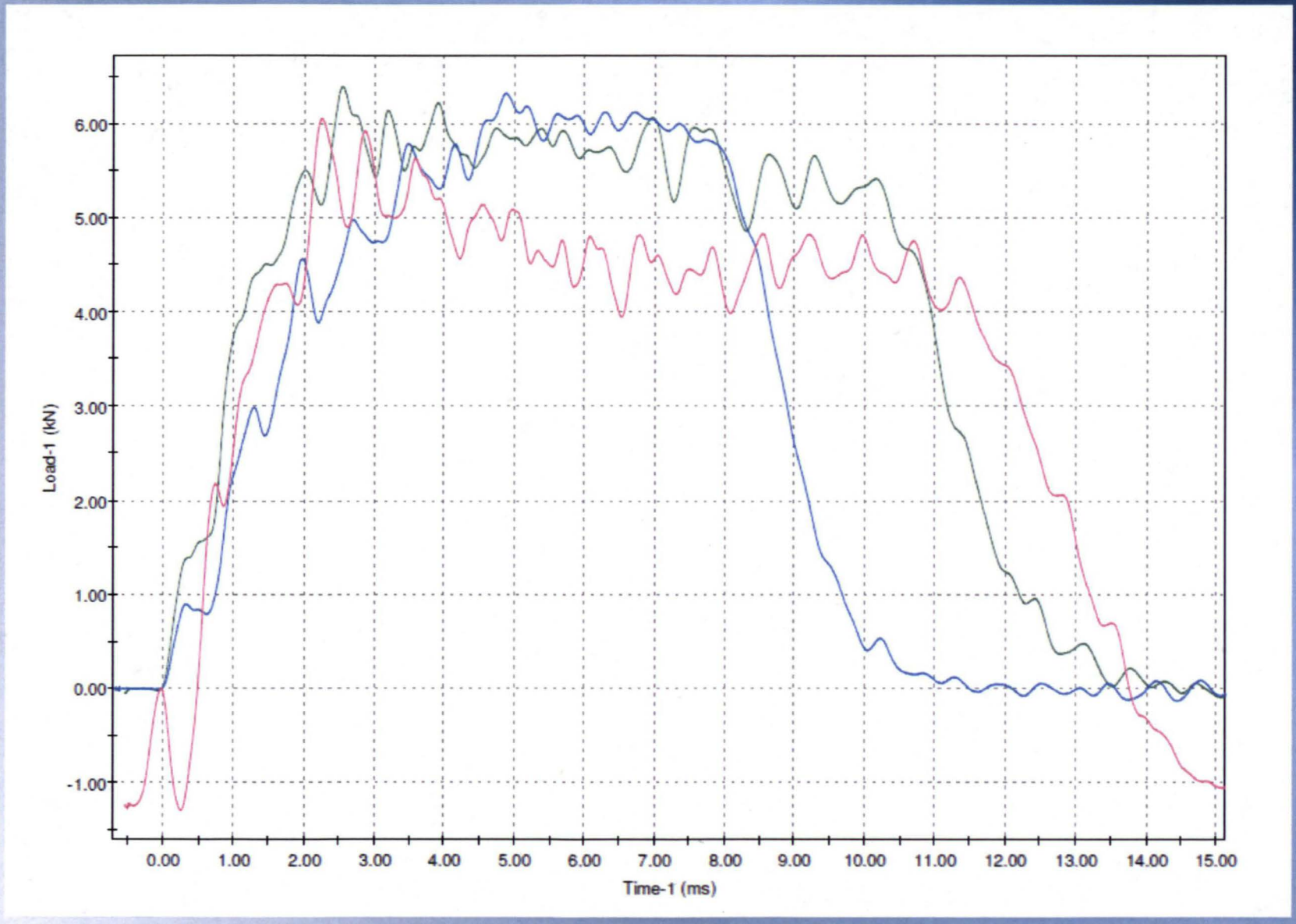
Instron 9250 Impact System



Force vs. Displacement, 100 J-300 J

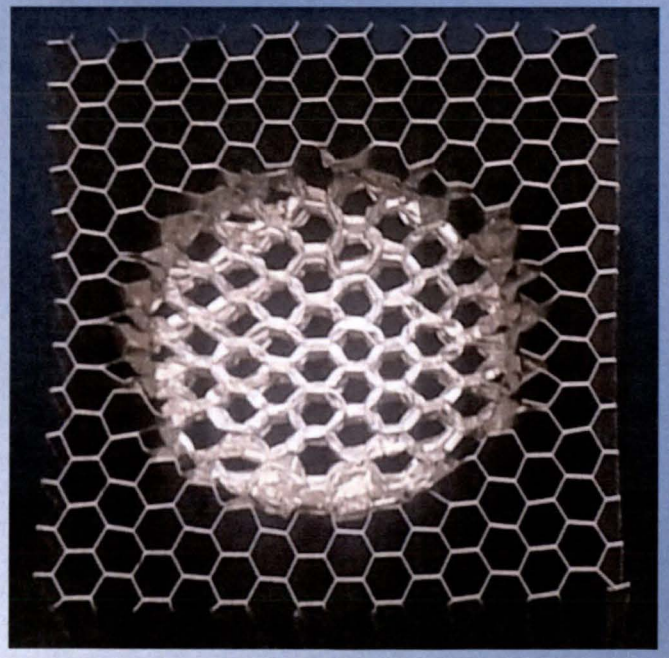


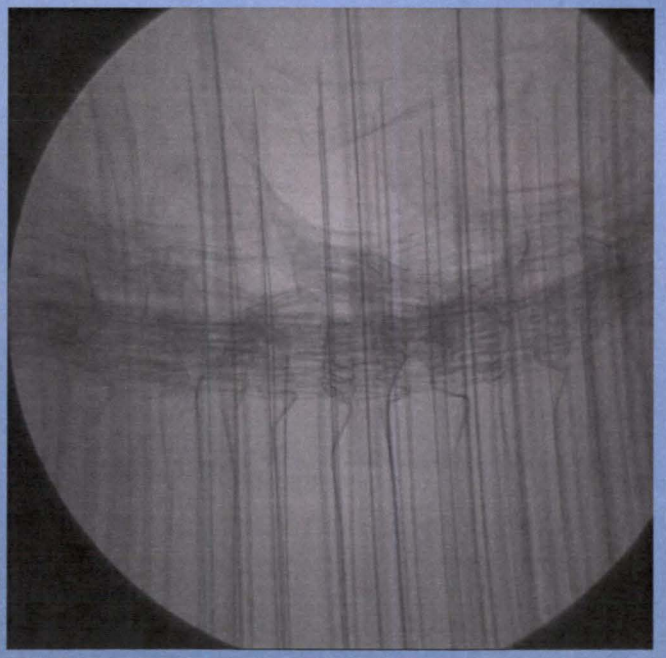
Force vs. Time, 100 J-300 J



X-Ray Evaluation

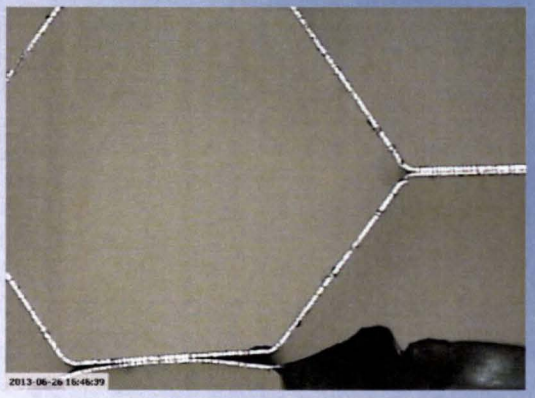
- Beam and applicability
- CT Scanner
    - CAT Scan
    - Cross-Sectioning



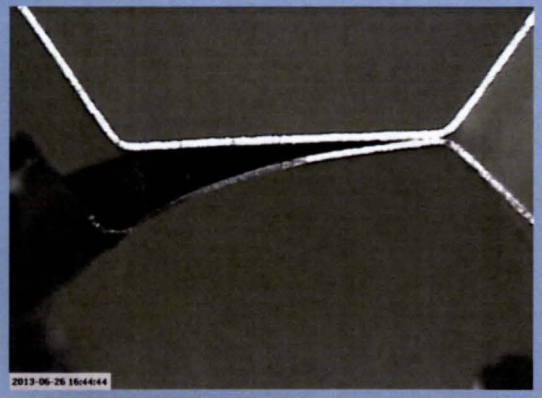


Metrology

- Micro-Vu Excel 654 UC
  - Cell wall



20x



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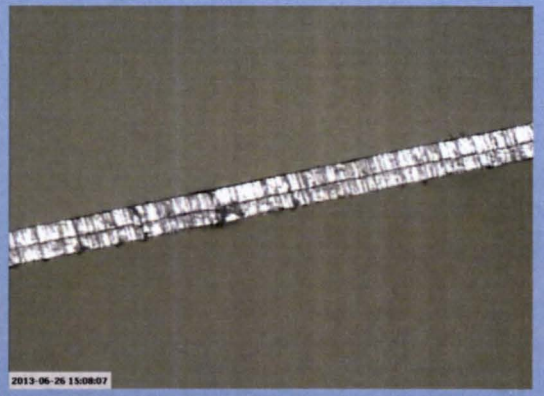

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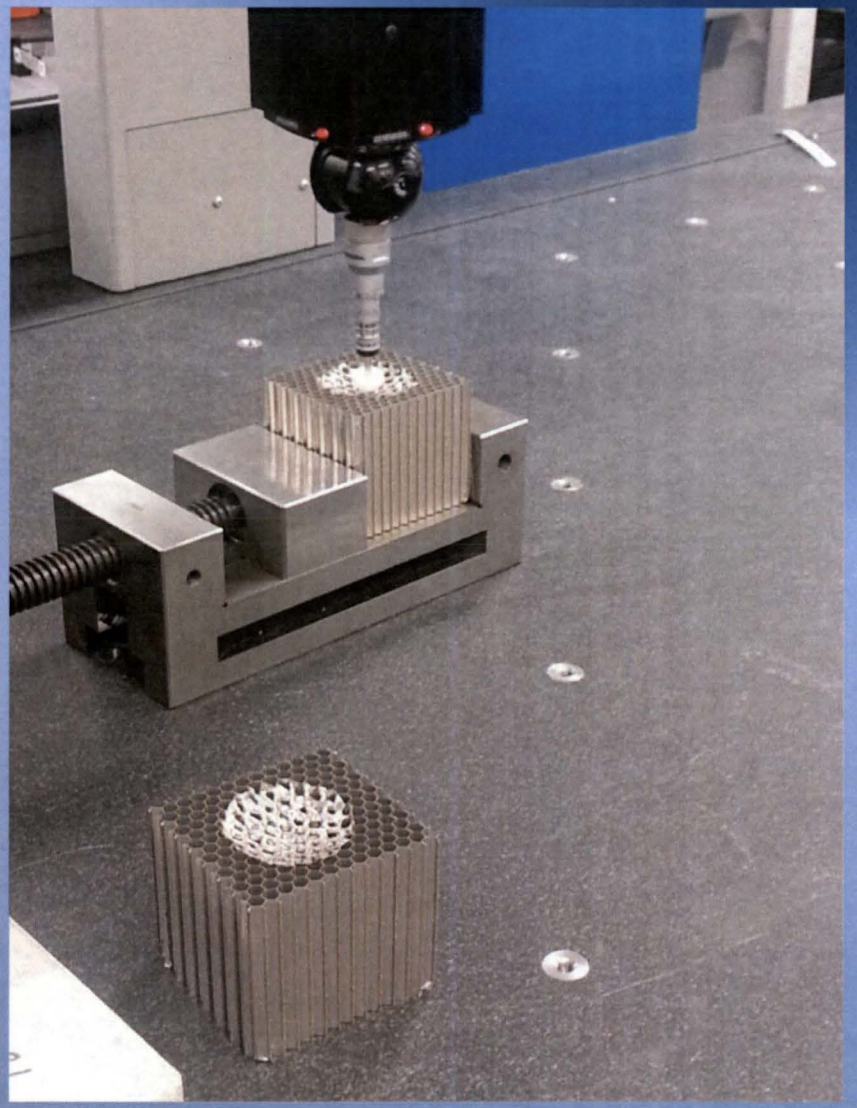
Metrology

- Micro-Vu Excel 654 UC
  - Cell wall
- Brown & Sharp Global Image 9128
  - Volumetric Analysis

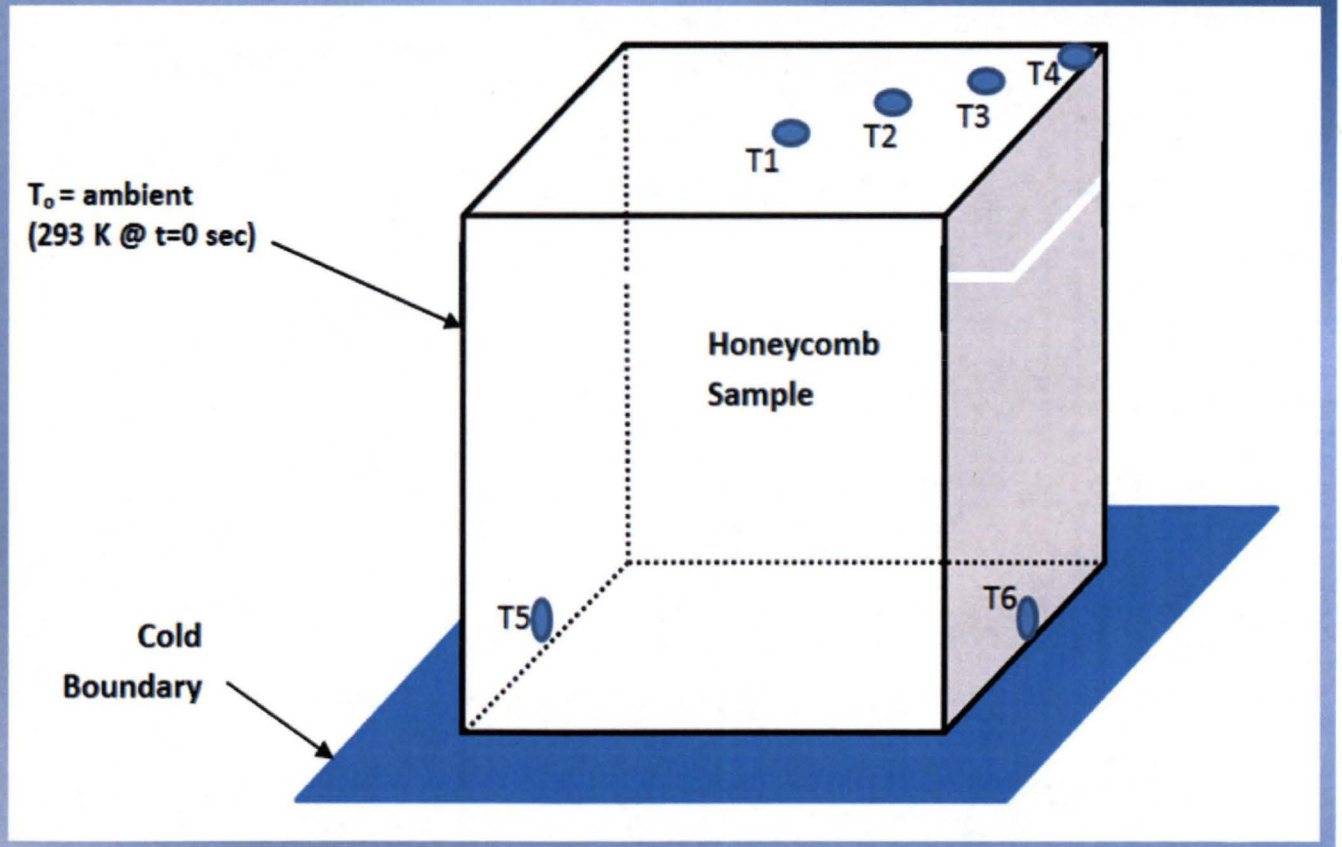


Metrology

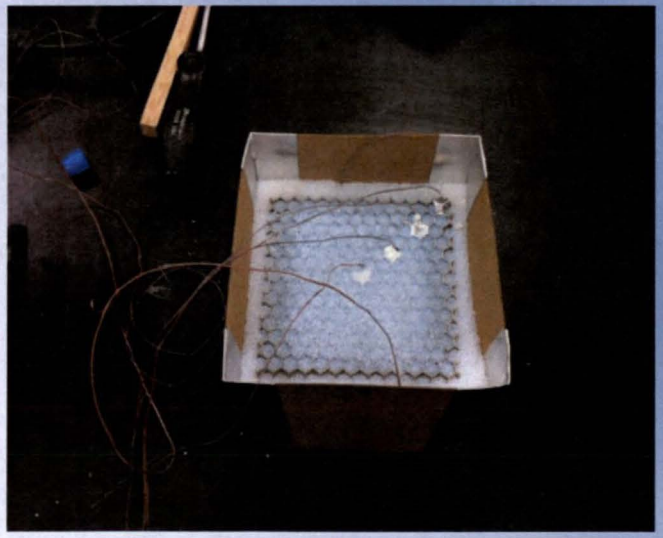
	Flatness (inches)	Depth 1 (inches)	Depth 2 (inches)	Depth 3 (inches)
Ambient (50 J)	0.0029	0.3736	0.3768	0.3754
LN_2 Immersed (50 J)	0.0019	0.3621	0.3617	0.3567
LN_2-cooled (50 J)	0.0018	0.3634	0.3646	0.3638
H_2O-Immersed (50 J)	0.0018	0.3489	0.3491	0.3481
Ambient (100 J)	0.0015	0.7230	0.7213	0.7257
LN_2 Immersed (100 J)	0.0027	0.6036	0.5973	0.5945
LN_2-cooled (100 J)	0.0028	0.5674	0.5689	0.5689
H_2O-Immersed (100 J)	0.0099	0.5831	0.5849	0.5841

Cryogenic Testing

- Thermocouple purpose
- Test Theory

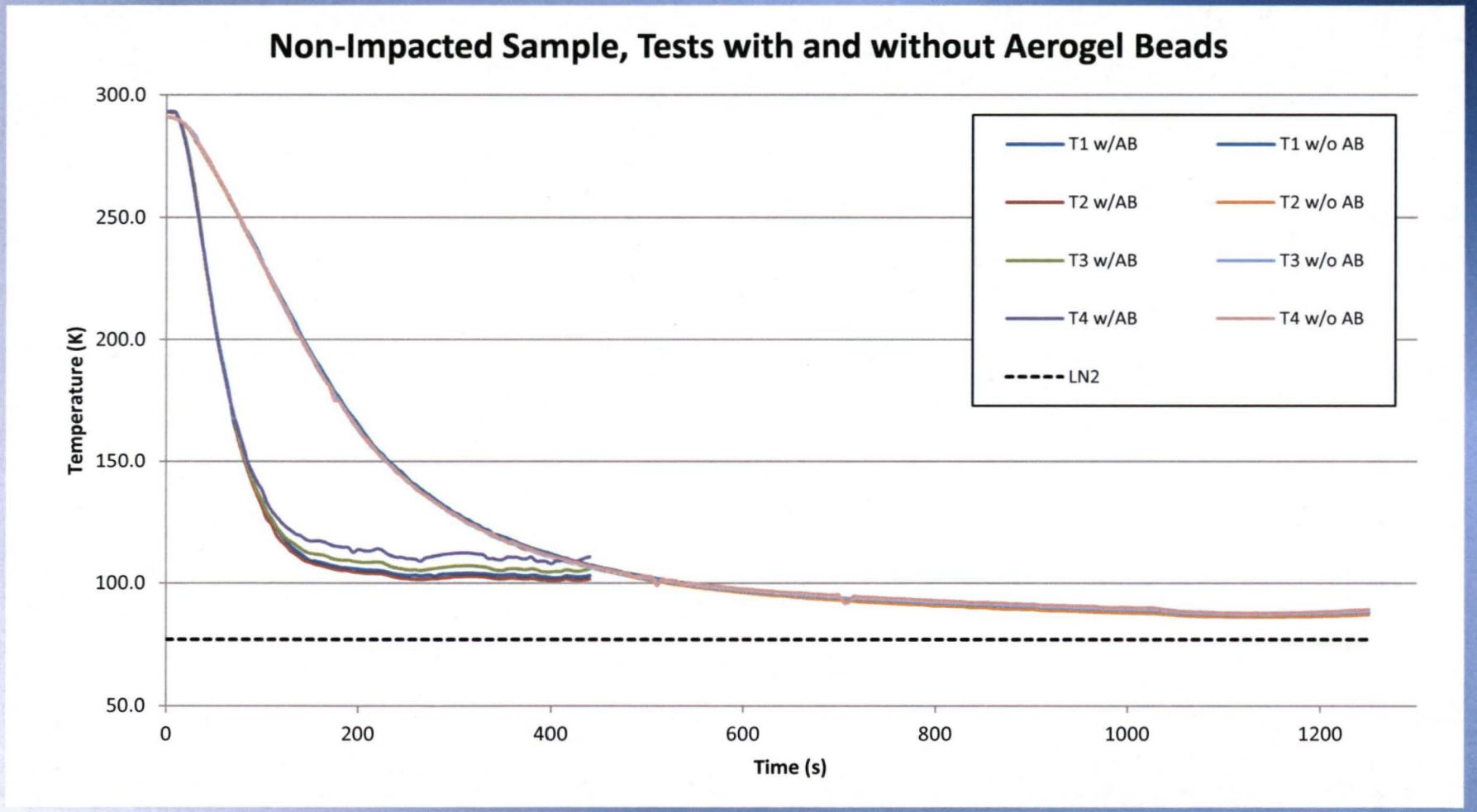


Cryogenic Testing



	Test #1 w/o Insulation	Test #2 With Insulation
Initial Sample Temp.	293.2 K	291.1 K
Avg. Steady State (SS) Temp.	101.8 K	86.1 K
Approx. Time to Reach SS Temp.	250 sec	1105 sec
Avg. ΔT Between Thermocouples	3.3 K	0.9 K
ΔT Between T1 and T4	7.2 K	0.7 K

Cryogenic Testing



Future Work

- Microscope → Adhesive
- High(er) impact testing
- High(er) impact cryogenic testing
  - More instrumentation, and refined test apparatus

Conclusions

- Impact Testing + Compression Testing
- X-Ray technology
  - CT Scanner
- Metrology
- Thermocouple
- Microscope
- Future:
  - White light scanner
  - Blue Light scanner
  - Flash thermography
  - Shearography

Acknowledgements

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